MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

DEPARTMENT OF MECHATRONICS
VI SEMESTER B. TECH (MECHATRONICS)
End Semester Assessment– May 2022

Subject: Artificial Intelligence **Subject Code: MTE 4059**

Time: 180 Minutes **Exam Time:**

MAX. MARKS: 50

Instructions to Candidates:

- ***Answer ALL the questions.***
- *Missing data may be suitably assumed and justified.*

		M	CO	PO	LO	BL
1A	For the multilayer feedforward network, perform single step error backpropagation and find out the updated weight w_{212} for the data given below. Z is the input vector, V and W are the weight matrices for hidden and output layer respectively. $Z = \begin{bmatrix} 1 \\ 3 \\ -1 \end{bmatrix}$ $V = \begin{bmatrix} 1 & 0 & 2 \\ 2 & 3 & 1 \end{bmatrix}$ $W = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$ Desired output is = [1 0] Consider the first layer to consist of unipolar sigmoid neurons and second layer to consist of softmax neurons. Assume learning rate as 1 and no bias inputs.	5	2	1	1	3
1B	Illustrate an algorithm mentioning the steps involved to train a neural network with ADAM type of optimizer. Assume there are ‘n’ no. of training vectors with ‘m’ no. of input features, use of sigmoid activation function and squared error type of loss.	3	3	2	2	4
1C	Explain two main advantages of a CNN over a fully connected DNN for image classification	2	4	1	1	2
2A	Classification of iris plants into three different species (iris-setosa, iris-versicolor and iris-virginica) has to be done using multilayer feedforward neural network, based on certain features. The classic iris dataset includes three species with 50 samples of each (a total of 150 samples). First five samples are shown below:	4	2,3	2	2	4

Id	Sepal Length (Cm)	Sepal Width (Cm)	Petal Length (Cm)	Petal Width (Cm)	Species
1	5.1	3.5	1.4	0.2	Iris-setosa
2	4.9	3	1.4	0.2	Iris-setosa

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<tr><td>3</td><td>4.7</td><td>3.2</td><td>1.3</td><td>0.2</td><td>Iris-setosa</td></tr>
<tr><td>4</td><td>4.6</td><td>3.1</td><td>1.5</td><td>0.2</td><td>Iris-setosa</td></tr>
<tr><td>5</td><td>5</td><td>3.6</td><td>1.4</td><td>0.2</td><td>Iris-setosa</td></tr>
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Supposing that you have designed a network with an input layer of 20 neurons, hidden layer of 10 neurons, followed by the output layer, answer the following questions:
i. What is the shape (matrix dimension) of the input training data considering 90% of the samples are used for training?
ii. What is the shape of the network output matrix?
iii. What is the shape of the weight matrix connecting the hidden layer to the output layer?
iv. Identify suitable activation functions for the neurons of the three layers.
v. You find that the network exhibits a high bias and a low variance. Describe what can be done to solve the problem.
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<tr><td>2B</td><td>Perform single step Hebbian learning of a single neuron network and calculate the updated weight. Consider input vector as
$X=[1\ -1]^t$, initial weight vector as $[2\ -1]^t$, learning rate as 1 and sigmoid activation function.</td><td>3</td><td>2</td><td>1</td><td>1</td><td>3</td></tr>
<tr><td>2C</td><td>Explain the RESNET model of convolutional neural network. Highlight the key improvements in this network to the previous ones.</td><td>3</td><td>4</td><td>1</td><td>1</td><td>2</td></tr>
<tr><td>3A</td><td>Consider a CNN composed of three convolutional layers, each with 3 × 3 kernels, a stride of 2, and zero padding. The lowest layer outputs 100 feature maps, the middle one outputs 200, and the top one outputs 400. The input images are RGB images of 200 × 300 pixels. What are the total number of trainable parameters in the CNN? Bias inputs can be neglected.</td><td>4</td><td>4</td><td>1</td><td>1</td><td>3</td></tr>
<tr><td>3B</td><td>Justify the correctness or otherwise of the statement:
While training a multilayer feedforward neural network with backpropagation training algorithm, it is okay to initialize all the weights to ‘one’.</td><td>3</td><td>3</td><td>2</td><td>2</td><td>4</td></tr>
<tr><td>3C</td><td>Consider fuzzy sets A and B defined in the universe of discourse U and V:

$$A = \frac{1}{0} + \frac{0.5}{1} + \frac{0.1}{2}$$

$$B = \frac{0.1}{1} + \frac{0.4}{2} + \frac{0.3}{3}$$

Perform Dienes-Rescher implication to interpret ‘if A then B’
Formula:

$$\mu_{Q_D}(x,y) = max[1 - \mu_{FP_1}(x), \mu_{FP_2}(y)]$$
</td><td>3</td><td>5</td><td>1</td><td>1</td><td>3</td></tr>
<tr><td>4A</td><td>Consider a two-input-one-output fuzzy system that is constructed from the following two rules:</td><td>5</td><td>5</td><td>1</td><td>1</td><td>3</td></tr>
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	$if\ x_1\ is\ A_1\ and\ x_2\ _{is}\ A_2, then\ y\ is\ A_1$ $if\ x_1\ is\ A_2\ and\ x_2\ _{is}\ A_1, then\ y\ is\ A_2$ Where, A1 and A2 are fuzzy sets with membership functions: $\mu_{A_1(u)} = \begin{cases} 1 - \left\lvert\frac{u}{2}\right\rvert\ if\ -2 \le u \le 2 \\ 1 - \left\lvert\frac{u}{2} - 1\right\rvert\ if\ 0 \le u \le 4 \end{cases}$ Suppose that the input to the fuzzy system is (x_1*, x_2*) = (0.8,1.4) and we use the singleton fuzzifier, Determine the output y* in the following situation: Mamdani Minimum inference engine with mean max membership defuzzifier					
4B	The set of input training vectors to a perceptron is as follows: $X_1 = \begin{bmatrix} 1 \\ -1.5 \end{bmatrix} \quad X_2 = \begin{bmatrix} 0.5 \\ 2 \end{bmatrix}$ The initial weight vector W1 is assumed to be: $W_1 = \begin{bmatrix} 1.5 \\ -1 \end{bmatrix}$ The learning constant is assumed to be 0.1. The desired response for X1 is d1= -1, d2= -1 respectively. Update the weights according to perceptron learning algorithm using the signum activation function.	3	3	1	1	2
4C	Describe in which case would you want to use the following activation functions: leaky ReLU and softmax.	2	5	1	1	3
5A	You are asked to develop a controller to regulate the temperature of a room. Knowledge of the system allows you to construct a simple rule of thumb: when the temperature is HOT then cool room down by turning the fan at the fast speed, or, expressed in rule form, IF temperature is HOT, THEN fan should turn FAST. Fuzzy sets for hot temperature and fast fan speed can be developed: for example $H = hot = \left\{\frac{0}{60} + \frac{0.1}{70} + \frac{0.7}{80} + \frac{0.9}{90} + \frac{1}{100}\right\}$ represents universe X in ◦F, and $F = fast = \left\{\frac{0}{0} + \frac{0.2}{1} + \frac{0.5}{2} + \frac{0.9}{3} + \frac{1}{4}\right\}$ represents universe Y in 1000 rpm. (a) From these two fuzzy sets construct a relation for the rule using classical implication. (b) Suppose a new rule uses a slightly different temperature, say ‘‘moderately hot,’’ and is	4	5	2	1	4

	expressed by the fuzzy membership function for ''moderately hot,'' or $$H' = \left\{\frac{0}{60} + \frac{0.2}{70} + \frac{1}{80} + \frac{1}{90} + \frac{1}{100}\right\}$$ Using max–min composition, find the resulting fuzzy fan speed. Formula: $$\mu_{P \circ Q}(x, z) = \max_{y \in V} min[\mu_P(x, y), \mu_Q(y, z)]$$					
5B	Let U and V be universe of discourse and A and B are fuzzy sets in U and V. A fuzzy If-Then rule is formed as: x is A' If x is A then y is B Use generalized Modes Ponens to derive a conclusion in the form y is B', where, A→B is interpreted using Mamdani Product implication $U = \{x_1, x_2, x_3\}$ V= $\{y_1, y_2\}$ $A = \left\{\frac{0.5}{x_1} + \frac{1}{x_2} + \frac{0.6}{x_3}\right\}$ $B = \left\{\frac{1}{y_1} + \frac{0.4}{y_2}\right\}$ $A' = \left\{\frac{0.6}{x_1} + \frac{0.9}{x_2} + \frac{0.7}{x_3}\right\}$	4	5	1	1	3
5C	Given two fuzzy sets A and B in universe of discourse X and Y, develop the fuzzy relation with minimum operator. $$A = \left\{\frac{0.2}{1} + \frac{0.3}{2} + \frac{0.7}{3}\right\} \quad B = \left\{\frac{0.9}{1} + \frac{0.4}{2}\right\}$$	2	5	1	1	3